

BEST AVAILABLE COPY

**THE KOREAN INTELLECTUAL
PROPERTY OFFICE**

This is to certify that annexed hereto is a true copy from the records of the Korean Intellectual Property Office of the following application as filed.

Application Number : Patent Application No. 2002-44638

Date of Application : July 29, 2002

Applicant(s) : Samsung Electronics Co., Ltd.

April 10, 2003

COMMISSIONER

COMPUTER SYSTEM WITH NAND FLASH MEMORY FOR BOOTING AND STORAGE

BACKGROUND OF THE INVENTION

5

Field of the Invention

The present invention relates to a computer system with a NAND flash memory for booting and storage.

10 Description of the Related Art

In a system such as a general PDA, mobile phone, set top box or the like, ROM or NOA flash memory is mainly used for the system drive memory and NOA flash memory is used as the data storage memory. Flash memory is suitable for data storage because it has a volatility in which data can be written and erased and no refresh is needed. In particular, NOA
15 flash memory is widely being used for booting and storage in a system that is not the high speed interface.

With the growth of the system market, there is recently requested a memory capable of supporting high speed access and large capacitance as well as being cost-effect due to the service variety, high functionality and high capacity in the system. However, the NOA flash
20 memory has a limitation in meeting such a request. Although DRAM meets such a request at the present, it is a volatile memory and is not suitable for data storage.

In the meanwhile, since the NAND flash memory is easy to realize a large capacitance and is cost-effect compared with the NOA flash memory, it is widely used as a large capacitive memory. Also, the NAND flash memory is easy to fabricate and has a good
25 integrity, its use as the booting memory was proposed.

In U.S. Patent No. 5,535,357, Dov Moral et al. entitled "Flash memory system providing both BIOS and user storage capability", an example of the flash memory used as the booting is disclosed. Referring to FIG. 1, in order to use a NAND flash memory as the booting, a flash controller 8 performs an interfacing between a NAND flash memory 9 and a system bus 2. Here, the NAND flash memory 9 has to store a separate emulation means. The emulation means is indicative of means for using a region of the NAND flash memory as the hard disk. The flash controller 9 intercepts the BIOS booting process and installs the emulation means in a system memory 3. In the construction of FIG. 1, the system booting is performed as follows.

10 First, a jump address for a BIOS region BS (located at block 1) is stored in a file system region FS (located at block 0) of a NAND flash memory 4. A memory mapping to the BIOS block BS is performed using a memory mapping circuit (or window circuit) arranged in the flash controller 8. By the memory mapping, an operating system region OS is moved to the system memory 3 to thereby perform the system booting.

15 However, in order to use the NAND flash memory as the system booting memory by the aforementioned conventional method, the NAND flash memory 4 should be partitioned into the file system region FS, the BIOS region BS, the operating system region OS and the user data region UD as shown in FIG. 1. Also, the NAND flash memory 4 has to have the emulation means which allows the NAND flash memory 4 to be recognized as the hard disk.

20 In addition, the flash controller 8 has to have the function to intercept the BIOS operating process and means for performing an address mapping to the BIOS region BS.

Thus, in the aforementioned conventional method, preparations for the NAND flash memory and the flash controller and their operational steps are complicated. To this end, there is caused a drawback in that it is not easy to apply the conventional method to a general
25 computer system.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a device which enables an easier use of a NAND flash memory as booting and storage in a general computer system.

5 It is another object of the present invention to provide a device which enables to perform an interfacing function more easily and efficiently in a computer system in which a NAND flash memory is used for booting and data storage.

It is a further object of the present invention to provide an interface unit performing data reading from and programming operations in a NAND flash memory used for booting
10 and data storage in a computer system.

Additional advantages, objects, and features of the invention will be set forth in part in the description which follows and in part will become apparent to those having ordinary skill in the art upon examination of the following or may be learned from practice of the invention. The objectives and other advantages of the invention may be realized and attained by the
15 structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

In an aspect of the present invention, there is provided a computer system comprising:
a system controller including a central processing unit and a memory bus controller and
operating in a first interface mode; a system memory connected with the system controller
20 through the system bus; a NAND flash memory for storing a system driving code, an
operating system program and a user data for the computer system; and an interface unit
communicating with the system controller through the system bus in the first interface mode
and communicating with the NAND flash memory in a second interface mode, the interface
unit being synchronized with a clock signal generated therein in response to a predetermined
25 command information and operating.

The interface unit comprises: a host interface unit communicating with the system controller through the system bus in the first interface mode; a register unit for storing a configuration information about the computer system and the NAND flash memory and the command information about the NAND flash memory; a buffer unit for storing data of the NAND flash memory; an oscillator for generating the clock signal in response to the command information; a state machine synchronized with the clock signal, for controlling an inner operation of the interface unit in response to the command information; and a NAND flash interface unit synchronized with the clock signal and communicating with the NAND flash memory by the state machine in the second interface mode.

10 The interface unit further comprises a power-up detector for applying a power sensing signal to the state machine when a power is applied, and an error correcting circuit synchronized with the clock signal, for performing an error test and correction on the data of the NAND flash memory.

The state machine comprises: a first block for controlling operations to program the data stored in the buffer unit and predefined error correcting parity bits in the NAND flash memory; a second block for controlling an operation to store the data read out of the NAND flash memory in the buffer unit; a third block for controlling an operation to boot the compute system by using the system booting code stored in the NAND flash memory; a fourth block for controlling an operation to generate the error correcting parity bits during the programming operation of the NAND flash memory and controlling an operation to correct an error by comparing the parity bits stored in the NAND flash memory with new parity bits during the read operation of the NAND flash memory, a fifth block for controlling an operation to erase the data stored in the NAND flash memory; and a sixth block for controlling a reset command applied to the NAND flash memory and resets of registers within the interface unit.

In another aspect of the invention, the interface unit comprises: a first interface unit communicating with the system controller through the system bus in the first interface mode; a second interface unit synchronized with the clock signal and communicating with the NAND flash memory in the second interface mode; a storage unit for storing information and data exchanged between the first and second interface units; and a control unit synchronized with the clock signal, for controlling a transmission of the information and data between the first and second interface units. The storage unit comprises: a register unit for storing a configuration information about the compute system and the NAND flash memory and the command information about the NAND flash memory; and a buffer unit for storing data of the NAND flash memory.

In another aspect of the invention, there is a booting method of a computer system with a NAND flash memory. The method comprises: a first step of copying a system booting code to a buffer from the NAND flash memory in response to a power applying detecting state; a second step of initializing the computer system according to the system booting code stored in the buffer and copying an operating system code to a programmable memory from the NAND flash memory; and a third step of executing the operating system code.

In addition, in a computer system of the invention, there are disclosed apparatus and method for reading and programming the NAND flash memory in a high performance when the controller reads data out of or programs data in the NAND flash memory.

In another aspect of the invention, there is provided a method for reading out data from a NAND flash memory in a computer system with a system controller, a buffer and the NAND flash memory. The method comprises: a first step of setting commands, addresses and pages to be read out to the NAND flash memory; a second step of copying the first page data of the pages to the buffer; and a third step of copying the second page data of the pages to the buffer from the NAND flash memory while transmitting the first page data from the buffer to

the system controller. The third step is repeated until the data copying of the set pages is completed. The data of the set pages are transmitted successively.

In another aspect of the invention, there is provided a method for programming data from a NAND flash memory in a computer system with a system controller, a buffer and the NAND flash memory. The method comprises: a first step of setting commands, addresses and pages to be programmed to the NAND flash memory; a second step of successively loading data necessary for the pages to be programmed from the system controller to the buffer; and a third step of sequentially executing a program for the pages by using the data loaded to the buffer. The program for another page is executed while the data to one page of the pages is loaded to the buffer.

It is to be understood that both the foregoing general description and the following detailed description of the present invention are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this application, illustrate embodiment(s) of the invention and together with the description serve to explain the principle of the invention. In the drawings:

- FIG. 1 is a block diagram of a conventional computer system;
- FIG. 2 is a block diagram of a computer system according to the present invention;
- FIGs. 3A and 3B are timing diagrams showing read operations of a NOA flash memory and a NAND flash memory respectively;
- FIG. 4 is a block diagram of an inner construction of the interface unit of FIG. 2;

FIG. 5 is a block diagram showing functional constructions of the state control unit of FIG. 4;

FIG. 6 is a flowchart showing an operational flow of the computer system of FIG. 2;

FIG. 7 is a flow diagram showing an operational flow of the compute system of FIG.

2 when a NAND flash memory is used for the system operation:

FIGs. 8 and 9 are flowchart and timing diagram showing a data read operation from a NAND flash memory using the interface unit of FIG. 4; and

FIGs. 10 and 11 are flowchart and timing diagram showing a data programming operation in a NAND flash memory.

10

DETAILED DESCRIPTION OF THE INVENTION

Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings. However, the present invention is not limited to the embodiments illustrated hereinafter, and the
15 embodiments herein are rather introduced to provide easy and complete understanding of the scope and spirit of the present invention.

FIG. 2 illustrates a construction of a computer system according to the present invention. Referring to FIG. 2, the computer system of the present invention includes a system controller 11 such as a central processing unit (CPU), a system bus 2, a system memory 3 such
20 as DRAM, a NAND flash memory 10 whose storage region is divided, and an interface unit 20 for interfacing data or signals between the system 2 and the NAND flash memory 10.

The system bus 2 connects the system controller 11, the system memory 3 and the interface unit 20 one another. The NAND flash memory 10 is used as a system bootstrap device as well as a data storage device. The NAND flash memory 10 has an internal data
25 region divided into three storage regions, i.e., BC, OS and UD regions. The BC region stores

system bootstrap codes, the OS region stores information on operating system, and the UD region stores general user data. The storage regions BC, OS and UD are divided according to kinds of data to be stored, and each storage region consists of a plurality of pages. The interface unit 20 is provided to operate for the system controller 11 which does not support the conventional NAND flash controller (14 in FIG. 4). The system controller 11 is provided with a core block 15, a peripheral circuit 16 and a memory bus controller 17. The memory bus controller 17 supports a program memory controller and a NOR flash memory controller, not an interface for NAND flash memory.

The interface unit 20 interfaces with the memory bus controller 17 through the system bus in a NOR flash interface mode and with the NAND flash memory 10 in a NAND flash interface mode. FIGs. 3A and 3B illustrates read operations in the NOR flash interface mode and the NAND flash interface mode, respectively. While the NOR flash memory can carry out a random access read operation, the NAND flash memory carries out the read operation by page unit rather than the random access read and requires a latency time of maximum 10 μ s. Due to the difference between the NOR flash interface mode and the NAND flash interface mode, the interface unit 20 of FIG. 2 is needed so as to use the NAND flash memory in a computer system which does not support the NAND flash interface mode.

As shown in FIG. 4, the interface unit 20 includes a host interface unit 21, a register unit 22, a buffer unit 23 an oscillator 24, a state machine 25, a power-up detector 26, an error correction circuit (ECC) 27, and a NAND flash interface unit 28.

In order to provide the NOR flash interface function between the interface unit 20 and the system controller 11, the host interface unit 21 exchanges address signals AD, data input/output signals DIO and control signals CRH with the system bus 2 connected to the system controller 11. The address signals AD include address signals used to store data in the SRAM register unit 22, the SRAM buffer unit 23 and the NAND flash memory. The data

signals DIO are read out/programmed from/into the NAND flash memory 10. The control signals CRH include control signals for operating the interface unit 20. The register unit 22 stores information related to the computer system configuration and command in response to control signals CRW1 and address signals ADR1, which are provided through the host interface unit 21. As one example of the information related to the system configuration and command, data signals DIO1 are exchanged between the host interface unit 21 and the register unit 22. The buffer unit 23 temporarily stores data to be read out/programmed from/into the NAND flash memory 10 in response to control signals CRW2 and address signals ADB1, which are provided through the host interface unit 21. Data signals DIO2 exchanged between the host interface unit 21 and the buffer unit 23 are data signals that are read out from the NAND flash memory 10 and transmitted to the system controller 11, or data signals that are provided from the system controller 11 and programmed into the NAND flash memory 10.

The register unit 22 and the buffer unit 23 are provided with SRAMs. The register unit 22 includes configuration registers and command registers. For example, the configuration registers store information on characteristics of the NAND flash memory 10 controlled by the interface unit 20. The characteristics include information on an IO depth ($\times 8$ or $\times 16$), a page size, a bit density, and error correction or non-correction. In case a write command is inputted to corresponding address, the command registers executes the write command and a command start signal CS is applied from the command register to the state machine 25. The register unit 22 exchanges data signals related to the system configuration and command with the state machine 25 in response to control signals CRW3 and address signals ADR2, which are inputted from the state machine 25 in order for internal operations. The buffer unit 23 exchanges data signals (system bootstrap code, read data or program data) DIO4 with the NAND flash memory 10 through the NAND flash interface unit 28 in response to control signals CRW4 and address signals ADB2, which are provided from the state machine 25.

The oscillator 24 generates a clock signal CLK for synchronizing an internal operation of the interface unit 20 in response to an activation signal OCE provided from the state machine 25. The clock signal CLK is provided to the error correction circuit 27 and the NAND flash interface unit 28. Although the clock signal CLK can be provided from an exterior of the interface unit 20, e.g., the system controller 11 of FIG. 2, through the host interface unit 21, the reason why the clock signal is generated in an inside of the interface unit 20 is to reduce a current consumption. In other words, the clock signal is not always applied to the interface unit 20 from its exterior but if a command is applied from an exterior of the interface unit 20 and set into the command register of the register unit 22, the oscillator 24 operates and thus the state machine 25 performs predetermined operations. If all operations are completed, the oscillator 24 stops its operation.

The state machine 25 functions as a central process unit which manages and controls the operation of the interface unit 20. As shown in FIG. 5, the state machine 25 is divided into a program state machine PSM, a read state machine RSM, an erasure state machine ESM, an interrupt state machine ISM, a bootstrap loading state machine BLM, and an ECC state machine ECM on the basis of functions.

The program state machine PSM controls an operation of programming data stored in the buffer unit 23 into an address which is previously assigned to the NAND flash memory 10, and also controls an operation of storing parity bits generated by the ECC state machine ECM into a spare address which is previously assigned to the NAND flash memory 10. The read state machine RSM controls an operation of storing data read out from the NAND flash memory 10 into address which is previously assigned to the buffer unit 23. The erasure state machine ESM controls an operation of erasing data stored in an address which is assigned to the NAND flash memory 10. The interrupt state machine ISM controls reset operations to the NAND flash memory 10 and the registers of the interface unit 20. The bootstrap loading state

machine BLM includes a bootstrap circuit and controls an operation of transmitting the bootstrap code stored in the NAND flash memory 10 to the buffer unit 23 in response to the power-up detection signal PWR which is an output of the power-up detector 26. Also, the bootstrap loading state machine BLM can share with the read state machine RSM. The bootstrap loading state machine BLM performs a general read operation and allows a page read operation to be performed in pipelined fashion according to predefined bootstrap codes. For example, assuming that the bootstrap code region BC of the NAND flash memory 10 is assigned to eight pages and a size of the buffer unit 23 contained in the interface unit 20 is equal to or larger than eight pages, eight-page data are read out from the BS region of the NAND flash memory 10 in pipelined fashion and transmitted to the buffer unit 23. The ECC state machine ECM controls an operation of generating parity bits during the program operation of the NAND flash memory 10, and performs an operation of correcting data of corresponding address by comparing stored parity bits with new parity bits during the read operation.

When the power is supplied to the computer system of FIG. 2, the power-up detector 26 generates the power-up detection signal PWR to initiate the internal registers, and activates the bootstrap loading state machine BLM of the state machine 25. In response to the error checking signal ECP provided from the state machine 25, the error correction circuit (ECC) 27 performs data error detection and correction using the parity bits generated during the read and program with respect to the NAND flash memory 10. The error correction circuit 27 simultaneously receives data transmitted between the NAND flash interface unit 28 and the buffer unit 23 and generates error correction codes. If there is a single bit error, the error correction circuit 27 corrects the signal bit error and transmits a corresponding error information signal E1 to the state machine 25. The NAND flash interface unit 28 transmits command and control signals CRN and address signals ADF for the NAND flash memory,

which are provided from the state machine 25, to the NAND flash memory 10 in the NAND flash interface mode, and interfaces data exchange between the NAND flash memory 10 and the interface unit 20. Accordingly, through the NAND flash interface unit 28, the NAND flash memory 10 provides the control signals required for the operations, i.e., a chip enable signal nCE, a read enable signal nRE, a write enable signal nWE, a write protect signal WP, an address latch enable ALE, a command latch enable signal CLE, and address signals ADF, receives a ready/busy signal R/nB, and exchanges data signals DIOF (bootstrap code, read or program data) with the NAND flash memory 10.

The power-up detector 26 and the error correction circuit 27, which are provided within the interface unit 20 of FIG. 4, can be installed outside the interface unit 20. For example, instead of the power-up detection signal PWR outputted from the power-up detector 26, a system reset signal applied from an exterior of the interface unit 20 can be used to start the system bootstrapping.

Hereinafter, there will be made a detailed description about the operations of the present invention in the computer system using the interface unit 20 in case the NAND flash memory 10 is used for the system bootstrapping and storage. The operations of the present invention are divided into a system bootstrapping operation using the NAND flash memory 10, a read operation to the NAND flash memory 10, and a program operation to the NAND flash memory 10. It should be understood that the other operations of the NAND flash memory 10, e.g., an erase operation, an erase/program verification operation, etc., are contained basically, and their descriptions will be omitted below.

FIG. 6 is a flowchart showing a basic process of an overall system bootstrapping in the computer system of FIG. 2. Referring to FIG. 6, if a power is on (S11), a power-on self test (POST) is carried out (S12). Here, the power-on self test (POST) is a process that the system controller 11 initiates and inspects respective hardware devices according to BIOS routine so

as to check whether or not the peripheral devices 16, e.g., the memory devices or hard disks, operate normally. If it is checked in the POST process that there is no malfunction in the hardware connected to the computer system, a bootstrap loading process from a bootstrap memory (i.e., the NAND flash memory 10) is carried out (S13). Then, an operating system (OS) program stored in the NAND flash memory 10 is loaded into the main memory (i.e., the system memory 3) (S14). The OS program retrieves information which is set to hardware and software of the computer system, and is executed to allow the computer system to operate normally (S15).

Hereinafter, there will be made a detailed description about the process of bootstrapping the computer system of FIG. 2 using the NAND flash memory 10 as the bootstrap memory. Referring to FIG. 7, if the computer system of FIG. 2 is powered on (S21), the power-up detector 26 generates the power-up detection signal PWR and informs the bootstrap loading state machine BLM contained in the state machine 25 of the power-up detection. Here, instead of using the power-up detector 26, the bootstrap loading state machine BLM can be informed of the power-up detection in response to the system reset signal.

If the power-up detection is checked, the bootstrap loading state machine BLM copies the bootstrap code stored in the NAND flash memory 10 to the buffer unit 23 (S22). The system controller 11 reads out the bootstrap code from the buffer unit 23 (S23). Additionally, the system controller 11 initializes the hardware devices of the computer system and then copies the OS program, which is stored in the NAND flash memory 10, to the system memory 3 (S24). Here, the step S24 corresponds to the step S14 of FIG. 6. Then, the system controller 11 executes the OS program stored in the system memory 3 to operate the computer system (S25). Here, the step S25 corresponds to the step S15 of FIG. 6.

The bootstrap code used in this invention is a code for initializing the hardware devices of the computer system and loading the OS program into the system memory 3, and

consists of a hardware initialization code and an OS program copy code. Additionally, if necessary, the bootstrap code can contain an interrupt vector which is executed when an interrupt command is applied to the system.

Since the NAND flash memory 10, as described above, is used as the bootstrap memory and also has the basic functions, such as the erase, program and write functions, the interface unit 20 can be allowed to support an interface environment between the system controller 11 and the NAND flash memory 10 in case the system controller 11 does not support the NAND flash interface function (most conventional system controllers have supported NOR flash interface function). In other words, as shown in FIGs. 2 and 3, the interface unit 20 performs the NOR flash interface function through the system controller 11 and the host interface unit 21, and performs the NAND flash interface function through the system controller 11 and the NAND flash interface unit 28. In order to operate the NAND flash memory 10 as data storage device, the interface unit 20 performs two processing methods, i.e., an interleave read and an interleave program.

FIGs. 8 and 9 are flowcharts of the interleave read operation, and FIGs. 10 and 11 are flowchart of the interleave program operation.

First, the interleave read operation will be described with reference to FIGs. 8 and 9. As described with reference to FIGs. 3A and 3B, while the NOR flash memory carries out the random access by word unit or byte unit, the NAND flash memory carries out the access operation by page unit. Therefore, the NAND flash memory must wait basically for a latency time of about maximum 10 μ s until data is read out (until the system controller 11 reads out data from the NAND flash memory 10). According to the present invention, the operation performance can be improved by reducing the latency time in the interleave read operation.

If the system controller 11 provides the interface unit 20 with information on address of the NAND flash memory 10 and information on page number to be read out, and

commands the interface unit 20 to read out data from the NAND flash memory 10 (S31), the interface unit 20 copies from the NAND flash memory 10 data of the page corresponding to the address assigned by the buffer unit 23 (S32). As shown in FIG. 9, the step S31 contains a period RCS for initializing the read operation and setting address and data amount with respect to the pages to be read out. If the data copy with respect to the current assigned page is completed (S33), the system controller 11 reads out the data of the current page from the buffer unit 23 and the interface unit 20 copies data of next page to the buffer unit 23 (S35). If the data copy of the next page is completed (S36), the system controller 11 checks whether or not the data read and copy are performed as many as the page number set to the interface unit 20 (S38). If not, the process proceeds to the step S35 so that the data read and copy operations with respect to next page are repeated. The process of reading out data of respective pages (e.g., page N) from the NAND flash memory 10 consists of a period RCAn of providing the read command and address with respect to the page, a period LATn of waiting for the latency time required for the read operation, and a period Rn of performing the data read/copy of corresponding page.

Specifically, referring to FIG. 9, after data of a first page (N, where N is a random page number) is copied from the NAND flash memory 10 to the buffer unit 23 (a period Rn), the data of the first page (N) is transmitted from the buffer unit 23 to the system controller 11 (a period CRn) while data of a second page (N+1) is copied from the NAND flash memory 10 to the buffer unit 23 (a period Rn+1 of the step S35). In other words, after data of the first page is copied to the buffer unit 23 (the step S32), the data transmission to the system controller 11 and the page read/copy are simultaneously performed (the step S35). In the same manner, while data of the second page (N+1) is transmitted from the buffer unit 23 to the system controller 11 (a period CRn+1), data of a third page (N+2) is copied from the NAND flash

memory 10 to the buffer unit 23 (a period R_{n+2}). The above procedures are repeated as many as the pages (e.g., N , $N+1$ and $N+2$) according to the flow of FIG. 8.

Latency times LA_{Tn} , LA_{Tn+1} and LA_{Tn+2} are spent in reading the respective pages when the pages are copied from the NAND flash memory 10 to the buffer unit 23. However, the system controller 11 can receive the read data from the NAND flash memory 10 in pipelined fashion by page unit without spending the latency times (about 10 μ s: LA_{Tn} , LA_{Tn+1} or LA_{Tn+2}).

Hereinafter, the interleave program operation will be described with reference to FIGs. 10 and 11. In order to program the NAND flash memory 10, an operation of loading to-be-programmed data into the page buffers of the NAND flash memory 10 is needed. The interleave program according to the present invention reduces the data loading time.

First, if the system controller 11 provides the interface unit 20 with information on address of the NAND flash memory 10 and information on page number to be programmed, and commands the interface unit 20 to program the NAND flash memory 10 (S41), the data corresponding to the to-be-programmed pages are loaded into the buffer unit 23. In other words, the program configuration information is provided to the register unit 22 of the interface unit 20 (PCS), and the data of the to-be-programmed pages are sequentially loaded into the buffer unit 23 (LP_n , LP_{n+1} and LP_{n+2}). Then, according to the order loaded into the buffer unit 23, program command and address with respect to a first page is provided (PC_{An}), corresponding data are loaded from the buffer unit 23 (Ln), and a program operation to the assigned page is executed (P_n) (S42). Here, as can be seen from the timing state of FIG. 9, it should be noted that data of next page (e.g., $N+1$) is loaded into the buffer unit 23 while the program operation is executed to a current page (e.g., N). If the program operation to the current page is completed (S43), the interface unit 20 performs the program operation to the next page ($N+1$), which is stored in the buffer unit 23, just like the program operation to the

first page ($PCAn+1 \rightarrow Ln+1 \rightarrow Pn+1$) (S45). If the program operation to the next page (i.e., the second page) is completed (S46), the system controller 11 checks whether or not the program operations are performed as many as the page number (e.g., three pages N to N+2) which is set to the interface unit 20 (S48). If not, the process proceeds to the step S45 so that the program operations to next pages are repeated.

According to the program operation to the NAND flash memory of the computer system of the present invention, since the program operations to the respective pages are executed after loading the data of the to-be-programmed pages into the buffer unit 23 in advance, the program operation (e.g., Pn) to other pages can be executed while the data of one page is loaded (e.g., $LPn+1$). As a result, the entire program data loading time for the NAND flash memory is reduced, so that the entire program time is reduced.

It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention. Thus, it is intended that the present invention covers the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

As described above, according to the method of the present invention, the NAND flash memory can be more simply and effectively used as the bootstrap device in the computer system. Particularly, with the use of the interface unit in the read operation to the NAND flash memory, the latency time is reduced and the entire program data loading time is also reduced in the program operation. Additionally, the NAND flash memory can be used as the bootstrap and storage device with respect to the system controller having the NOR flash interface mode. As a result, the present invention proposes a method which can more easy and efficiently uses the NAND flash memory as the bootstrap and data storage device, thereby reducing costs required for the system configuration.

**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☐ FADED TEXT OR DRAWING
- ☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☒ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.